

(12) **United States Patent**  
**Zhu et al.**

(10) **Patent No.:** **US 9,728,858 B2**  
(45) **Date of Patent:** **Aug. 8, 2017**

(54) **ELECTRONIC DEVICES WITH HYBRID ANTENNAS**

(56) **References Cited**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

4,016,490 A 4/1977 Weckenmann et al.  
4,614,937 A 9/1986 Poujois  
(Continued)

(72) Inventors: **Jiang Zhu**, Sunnyvale, CA (US);  
**Rodney A. Gomez Angulo**, Sunnyvale,  
CA (US); **Qingxiang Li**, Mountain  
View, CA (US); **Robert W. Schlub**,  
Cupertino, CA (US); **Hongfei Hu**, Santa  
Clara, CA (US)

FOREIGN PATENT DOCUMENTS

CN 1343380 4/2002  
CN 1543010 11/2004  
(Continued)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

OTHER PUBLICATIONS

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 239 days.

The ARRL Antenna Book, Published by The American Radio Relay  
League.\*

(Continued)

(21) Appl. No.: **14/260,800**

*Primary Examiner* — Hoang Nguyen

*Assistant Examiner* — Awat Salih

(22) Filed: **Apr. 24, 2014**

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;  
G Victor Treyz; Tianyi He

(65) **Prior Publication Data**

US 2015/0311594 A1 Oct. 29, 2015

(57) **ABSTRACT**

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 13/10** (2006.01)  
(Continued)

An electronic device may be provided with hybrid planar  
inverted-F slot antennas and indirectly fed slot antennas. A  
hybrid antenna may be used to form a dual band wireless  
local area network antenna. An indirectly fed slot antenna  
may be use to form a cellular telephone antenna. Antenna  
slots may be formed in a metal electronic device housing  
wall. The housing wall may have a planar rear portion and  
sidewall portions that extend upwards from the planar rear  
portion. The slots may have one or more bends. A hybrid  
antenna may have a slot antenna portion and a planar  
inverted-F antenna portion. The planar inverted-F antenna  
portion may have a metal resonating element patch that is  
supported by a support structure. The support structure may  
be a plastic speaker box containing a speaker driver that is  
not overlapped by the metal resonating element patch.

(52) **U.S. Cl.**  
CPC ..... **H01Q 13/10** (2013.01); **H01Q 1/2266**  
(2013.01); **H01Q 1/243** (2013.01); **H01Q**  
**9/0421** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 9/0421; H01Q 1/38; H01Q 13/10;  
H01Q 1/241–1/244; H01Q 13/085; H01Q  
13/16; H01Q 13/18  
(Continued)

**20 Claims, 14 Drawing Sheets**

